

**LAYERED FILTERING STRUCTURE****Field of the invention.**

5 The present invention relates to a layered filtering structure which is adapted for micro-filtration purposes. The term "micro-filtration" refers to filtering structures which are able to retain particles with a maximum size of between 0.5  $\mu\text{m}$  and 10  $\mu\text{m}$ , in particular below 2  $\mu\text{m}$ .

**Background of the invention.**

10 Presently available filter material for applications such as micro-filtration and for in situ cleanable filtration media conveniently comprise ceramic membrane layers fixed to the surface of porous sintered metal powder or metal fiber substrates. The high pressure drop across these filter laminates, however, is a considerable drawback since the filtering  
15 process requires additional energy due to the high pressure and robust mechanical supports for the filter layers. In addition, repeated backflushing is difficult and, after all, the ceramic layers are quite brittle, which adversely affects durability.

**Summary of the invention.**

20 It is an object of the present invention to avoid the drawbacks of the prior art.

It is also an object of the present invention to provide a filtering structure adapted for microfiltration without causing high pressure drops across  
25 the structure.

It is still another object of the present invention to provide a filtering structure which allows for repeated backflushing.

According to a first aspect of the present invention, there is provided a  
30 layered filtering structure which comprises at least a first layer and a second layer. Each layer comprises a web of metal fibers which have been sintered. The two layers are in contact with each other. The first layer, at the upstream side, so most close to the filter inlet side, has a porosity below 55 %. The second layer, at the downstream side, so  
35 closer to the filter outlet side, has a porosity which is at least 20 %

greater than the porosity of said first layer. Preferably the porosity of the second layer is greater than 80 %.

5 The first layer with the lower porosity determines the filter rating, i.e. the size of the particles the majority of which still pass the filter.

The fibers in the first layer preferably have a diameter of less than 3  $\mu\text{m}$ , e.g. less than 2.5  $\mu\text{m}$ , e.g. 2  $\mu\text{m}$ .

10 The first layer preferably has a weight ranging from 300  $\text{g/m}^2$  to 600  $\text{g/m}^2$  so that its thickness is limited to a range of between 0.05 mm to 0.15 mm. Generally, the pressure drop over a filter is about proportional to its thickness. In this case, the limited thickness of the first layer limits the resultant pressure drop to an acceptable degree. The degree of pressure drop over the second layer is considerably lower than the pressure drop over the first layer due to the greater porosity of the  
15 second layer. So the total pressure drop over the whole filtering structure is about equal to the limited pressure drop over the first layer. An incoming fluid is immediately able to expand in the second layer once it has passed the first layer.

20 The diameter of the fibers in the second layer is preferably three times greater than the diameter of the fibers in the first layer.

In order to obtain the difference in porosity between the first layer and the second layer, the first layer is sintered and compacted separately  
25 and in advance. Only thereafter, this sintered and compacted first layer is brought in contact with the second layer and a second sintering operation takes place to sinter the fibers in the second layer and to bond the two layers together.

30 The reason for the separate sintering and compacting step of the first layer can be explained as follows.

Compacting two or more layers of metal fiber webs together leads to a degree of porosity in the layers which is about the same over the whole

layered structure, and this is to a great extent independent of the fiber diameter in the different layers. This is in contrast with other filter media such as filter powders or filter particles. By separately sintering and compacting the first layer in advance, it is avoided that the second layer is compacted to more or less the same degree of the first layer.

In a preferable embodiment of the invention, the first layer has at least one even smooth surface in order to provide a good contact with the second layer.

10 A cold isostatic pressing operation is to be preferred for the compacting operation of the first layer, since this allows obtaining a homogeneous filter medium. Cold isostatic pressing, however, leads to a slightly rough surface and not to an even and smooth surface. Preference is here given to a cold isostatic pressing operation where the pressure is applied from one side and where the other side of the layer rests on an even and smooth support in order to obtain an even and smooth surface.

Preferably a wire net is fixed as support to the first layer or to the second layer. Most preferably the filtering structure is sandwiched between a first wire net fixed at the first layer at the inlet side and a second wire net fixed at the second layer at the outlet side. The meshes of the first wire net are smaller than the meshes of the second wire net. The diameters of the wires of the first wire net are smaller than the diameters of the wires of the second wire net.

25 Next to the function of support the first wire net still has another function and advantage. This first wire net generates some turbulence in the incoming flow which improves the anti-fouling behavior.

According to a second aspect of the present invention, there is provided a method of manufacturing a layered filtering structure. The method comprises the following steps :

30 (a) sintering a web of metal fibers to form a first layer ;

- (b) compacting the first layer to a porosity below 55 % ;
- (c) providing a web of metal fibers to form a second layer ;
- (d) bringing the first compacted layer and the second layer in contact with each other to form a layered assembly ;
- 5 (e) sintering the layered assembly to form a coherent entity wherein the second layer has a porosity which is at least 20 % higher than the porosity of the first layer.

Preferably the compacting step is done by means of a cold isostatic pressing operation.

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#### **Brief description of the drawings.**

The invention will now be described into more detail with reference to the accompanying drawing wherein

- FIGURE 1 shows an enlarged view of a cross-section of a layered filtering structure according to the invention.

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#### **Description of a preferred embodiment of the invention.**

##### **First Example.**

Referring to FIGURE 1, a layered filtering structure 10 according to the invention comprises a first layer 12 of a sintered and compacted fiber web. The fibers in the first layer have a diameter of 2  $\mu\text{m}$ . The weight of the first layer is 450 g/m<sup>2</sup>. The thickness is about 0.10 mm.

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The first layer 12 is via a smooth and even surface direct in contact with a second layer 13 of a sintered fiber web. The fibers in the second layer have a diameter of 8  $\mu\text{m}$ . The weight of the second layer is 225 g/m<sup>2</sup>.

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A first wire net 14 is fixed to the first layer 12. This first wire net 14 has been rolled to a thickness of 0.17 mm and has 48 meshes per inch (1 inch = 25.4 mm). Its weight is 380 g/m<sup>2</sup>.

A second wire net 15 is fixed to the second layer 13. This second wire net 15 has a thickness of 0.45 mm and has 40 meshes per inch. Its weight is 1220 g/m<sup>2</sup>.

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	First layer	Whole filter
Weight (g/m <sup>2</sup> )	450	2275
Thickness (mm)		1.02
Global porosity (%)		72.22
Textest		
Average (liter / dm <sup>2</sup> )		3.00 ± 15%

**Bubble point pressure test**

Average (Pa)	27000 ± 15%	24520 ± 15%
Filter rating (μm)	1.37 ± 15%	1.51 ± 15%

**Second Example.**

5 The same tests have also been applied to another layered filtering structure according to the invention. The difference with the structure of the first example, is now that the first layer is compacted not in an isostatical way. The first layer is now compacted between two plates until a thickness of about 0.10 mm is obtained.

	First layer	Whole filter
Weight (g/m <sup>2</sup> )	450	2275
Thickness (mm)	0.11	1.02
Global porosity (%)	46.63	72.22
Textest		
Average (liter / dm <sup>2</sup> )	3.72 ± 15%	5.72 ± 15%

**Bubble point pressure test**

Average (Pa)	18750 ± 15%	17430 ± 15%
Filter rating (μm)	1.97 ± 15%	2.12 ± 15%

Other embodiments according to the invention may be envisaged. As a matter of example only, following layered filtering structures are given :

diameter of filaments in first layer with low porosity ( $\mu\text{m}$ )	diameter of filaments in second layer with high porosity ( $\mu\text{m}$ )
4	12
6.5	22
8	30

- 5 The material used for the filtering structure according to the invention may be conventional compositions such as stainless steel 316®, Hastelloy®, Inconel® or Nichrome®. The latter composition can be applied for gas filtration at a high temperature.